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ABSTRACT

The study attempted to determine the extent to which a mathematics laboratory would enable both slow and gifted learners to gain in achievement in mathematics and to develop more positive attitudes toward mathematics. On the basis of ability, achievement in school, and results on the California Achievement Test, 75 fourth, fifth, and sixth grade students from each of two schools were selected as the research group, and 75 in one school and 40 in another were identified as the control group. Two mathematics laboratories in two elementary schools were put into operation and students attended 45-minute laboratory sessions twice weekly. Sessions were conducted on a diagnose-prescribe model, focusing on the areas where students needed additional work. Posttests for achievement and attitude were administered when the laboratory sessions concluded. The study found that mathematics laboratories used with slow learners and with gifted learners facilitated a slightly increased academic achievement in both cases, with more of an increase occurring at the lower grade levels. The laboratories also facilitated an increased positive attitude toward mathematics, with a significant increase occurring in the school located in a deprived area. There was no significant difference in achievement scores between laboratory and control groups. (Author/DT)

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Final Report

Project No. 9-G-038
Grant No. OEG-7-9-530038-0125

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A Study of the Effect of Mathematics Laboratories on the Mathematical Achievement and Attitude of Elementary School Students

July, 1972

U. S. Department of Health, Education, and Welfare

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AUTHOR'S ABSTRACT OF:

A Study of the Effects of Mathematics Laboratories on the Mathematical Achievement and Attitude of Elementary School Students

Purpose

1. To determine to what extent a mathematics laboratory would enable slow learners to gain in achievement in mathematics.
2. To determine to what extent a mathematics laboratory would enable academically gifted learners to gain in achievement in mathematics.
3. To determine to what extent a mathematics laboratory would enable slow learners and academically gifted learners to develop more positive attitudes toward mathematics.

Methodology

Following an initial screening of fourth, fifth, and sixth grade students' cumulative record folders to ascertain ability and achievement, four hundred students were selected and given the California Achievement Test. From this group seventy-five students in each of two schools were selected as the research group and seventy five in one school and forty in another were identified as the control group. Both groups of students were given a mathematics attitude scale.

Two mathematics laboratories in two elementary schools were operationalized in mid-September. Students attended 45 minute laboratory sessions twice weekly. The sessions were conducted on a diagnose-prescribe model, focusing on the areas where students needed additional work.

Post test for achievement and attitude were administered in mid-May when the laboratory sessions concluded.

Results:

1. Mathematics laboratories used with slow learners facilitated a slightly increased academic achievement, with more of an increase occurring at the lower grade levels.
2. Mathematics laboratories used with academically gifted learners facilitated a slightly increased academic achievement, with more of an increase occurring at the lower grade levels.
3. Mathematics laboratories facilitated an increased positive attitude toward mathematics, with a significant increases occurring in the school located in a deprived area.

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U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
National Center for Educational Research and Development
Regional Research Program
Dallas, Texas

PREFACE

Credit is given to Danny Higdon and Juanita Blessinger, graduate students, who organized and instructed in the laboratories. They also assisted with the research design and analysis of the data.

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INTRODUCTION

Statement of the Problem

It was the purpose of this study to explore the effects of a mathematics laboratory on the achievement and attitude of fifth and sixth grade students from two schools, A (middle-class) and B (culturally deprived).

Need for the Study

In most elementary classrooms, teachers do not have the time, facilities, or methods to teach slow learners as well as talented students. Consequently the teacher spends most of her time teaching the "average" student. The slow learners fall further behind, while the talented become bored and create discipline problems. Attention, therefore, should be given to innovative curriculum modifications growing out of the diversity of the student population and the inexperience of the faculty in these situations.

It is in the elementary school that the child forms attitudes concerning mathematics. In far too many cases, because of overcrowded classrooms, a lack of learning materials, and teachers unskilled in modern methodology, elementary school students form negative attitudes toward mathematics which results in their disliking the subject throughout the remainder of their lives.

The use of language laboratories has been quite successful in teaching language arts and communication skills and in creating more positive attitudes. The mathematics laboratory has been suggested as a prime innovation for teaching both computation skills

and concepts and in creating more positive attitudes toward the subject, especially for slow learners. It would seem essential that a solution to this problem should be found immediately. For although there seems to be a consensus of opinion concerning the value of mathematics laboratories, there have been few controlled studies of their effectiveness in relation to achievement.

Review of Related Literature and Research

Glennon reviewed several studies which compared arithmetic achievement in American schools with schools in other English speaking countries. All of the reported studies revealed that the children in American schools were achieving at a lower level in arithmetic when compared with children in Denmark, England, and Scotland. These studies would seem to imply that additional study is needed concerning the approaches to teaching mathematics that are being used in this country.

Phillips also states, "The student of low general ability, who is also likely to be a low achiever in mathematics, may with the proper program and improved methods of teaching, be able to enter the labor market less vulnerable to lurking unemployment possibilities."

According to Suppes, "The success of mathematics teaching depends upon understanding and providing successful practical remedies for the difficulties that students encounter. In our increasingly technological age it is of greater importance than ever before that we, as educators, recognize the need for

clear analysis of students' learning difficulties and the pressing need to develop theories that adequately deal with these difficulties."

Objectives

The primary objectives of the study were:

1. To determine to what extent a mathematics laboratory enables slow learners to gain in achievement in mathematics.
2. To determine to what extent a mathematics laboratory enables academically gifted learners to gain in achievement in mathematics.
3. To determine to what extent a mathematics laboratory enables slow learners and academically talented learners to develop more positive attitudes toward mathematics.

Hypotheses

The null hypotheses tested for this study were:

H_1: There will be no significant difference between IQ scores at school A and school B.

H_2: There will be no sifnificant difference between pre achievement of school A and school B.

H_3: There will be no significant difference between pre and post achievement in mathematics for each school.

H_4: There will be no significant differenc e between pre and post attitudes.

H_5: There will be no significant difference between IQ scores and changes in attitude.

H_6: There will be no significant difference between IQ scores and change in achievement in mathematics.

PROCEDURES

Description of the Population

During the 1969-70 school year, two mathematics laboratories were established in a suburban school district north of Houston, Texas. The total enrollment for that district during the 1969-70 school year was 15,347. The two laboratories were placed in contrasting social and economical geographical locations within the district in order to test the effects of such laboratory approaches on these two student populations. The two schools (School A and School B) were located approximately two and one-half miles apart.

School A was located in a predominately white middle class neighborhood while School B was situated in a low-socio-economic area. School A's enrollment for that semester was 886 (grades 1-6) with a staff of 28 classroom teachers, two teacher aides, and one Special Education Teacher. The student population was 100% anglo while the teaching staff consisted of 10% Negro.

School B's laboratory facilities were located in a low-socio-economic area of the district. The student and teaching make-up for School B consisted of 1003 students in grades 1-6, and an administrative staff of 34 classroom teachers, one teacher aide, and one Special Education Teacher. The student population for School B was approximately 23% Negro with a teaching staff of 81% Anglo and 19% Negro.

Laboratory Facilities

Laboratory facilities for School A were located in a 22' by 15' room equipped with three chalkboards (lowered for student's

use), one bulletin board, three work tables (no desks), and upper-lower storage space across one end of the room. The room was also equipped with a lavatory, fluorescent lamps, and central air and heat.

School B's laboratory facilities were housed in a 24' by 30' classroom consisting of panelled walls, tile floor, and acoustical tile ceiling. All furniture (tables, chairs, and desks) and storage space was movable to provide for flexibility with the laboratory setting. A chalkboard (4' by 24') lowered for student use was placed at one end of the room. This room was equipped with central air and heat.

Laboratory Materials

Materials used in both laboratories were of the commercial and homemade type. Much of the materials used during the year were developed and made by the laboratory instructors and students. Commercial aids that could not be replicated were purchased at the beginning of the experimental program.

Tape recorders, film strips, film strip projectors, listening stations, and 16 MM projectors were furnished both schools by the central supply office of the district. Mathematical games and puzzles, measuring devices, scales, and self-instruction programs were used on a loan basis from teachers and students.

Laboratory Staff

The teaching staff for the laboratories consisted of three

instructors: (a) one full-time instructor employed by the school district who taught at School A in the mornings and at School B in the afternoons, and (b) two doctoral students (both half-time) employed by the University of Houston, both majoring in Curriculum & Instruction (Elementary Mathematics). (One doctoral student taught at School B during the mornings while the full-time instructor was at School A. At noon each day the full-time instructor changed to School B for an afternoon laboratory session and was replaced in School A by the second doctoral student for the afternoon laboratory).

Procedures for Selecting Laboratory Subjects

Cumulative folders for all students enrolled in grades 4, 5, 6, at both schools were examined. Criterion for subject selections follows:

A. IQ

1. Otis Quick Scoring Mental Ability: IQ scores greater than 70.

B. Achievement

		Grade Equivalent
1. Accelerated Students		
(1a) Grade 4:	Gray-Votaw-Rogers Test	<5.0
(1b) Grade 5:	California Arith. Test	<6.0
(1c) Grade 6:	California Arith. Test	<7.0
2. Remedial Students		
(1a) Grade 4:	Gray-Votaw-Rogers Test	<3.5
(1b) Grade 5:	California Arith. Test	<4.5
(1c) Grade 6:	California Arith. Test	<5.5

C. Attendance and Mathematics Grades

If each of (A) and (B) above was satisfied, consistency of

of grades in mathematics as well as the attendance of the student was examined.

The initial screening yielded 236 students from School A and 164 students from School B. The California Achievement Test (CAT) was administered to these students. The Upper Primary Form W was given to all students with grade equivalents of less than 3.5. All others were given Elementary Form W.

Raw scores from each grade level were ranked from high to low at both schools. At School A, the highest 20 scores for each grade level were chosen. Ten students randomly chosen from these 20 constituted the accelerated experimental group from each grade level, with the remaining 10 making up the Control Groups. Similarly, 15 students were chosen randomly from the 30 lowest scores for the remedial experimental and control groups for each grade level.

At School B, such a break-down was possible only for all of grade 5 and remedial 4th grade students. Thus, control groups were set up for only 3 groups. A random selection of 10 accelerated subjects from each of grades 4 and 6 were taken from test scores not less than 1 month above normal grade placement (greater than 4.1 and 6.1 respectively), since less than 20 scores fell within this range for each grade. Fifteen remedial 6th grade subjects were also randomly chosen from those at least 1 month below grade placement.

Scheduling Laboratory Activities

Since the students selected for participating in the laboratory were grouped according to a diagnosis of the problems on the CAT pre-test, those with similar learning difficulties attended laboratory

sessions at the same time. Accelerated students met in groups of ten and three groups of five students were formed for remediation at each grade level for each school. These twelve groups of students from each school were scheduled to attend forty-five minute sessions in the lab on alternating days (i.e. Monday-Wednesday or Tuesday-Thursday) so that regular class time would not be interrupted two consecutive days. Due to Ability Grouping within the schools, it was often usually convenient to include students from the same classroom in one group. Sessions were held from 8:30-3:15 Monday through Thursday. Friday was used each week by the instructors for planning activities, bulletin boards, constructing laboratory instructional materials, and evaluating different aspects of the week's work. Regular laboratory sessions were held from mid-September to mid-May.

Instruments Used and Collection of Data

The arithmetic sub test of the CAT, Elementary Form W was used as the pre-test instrument for the measurement of achievement in arithmetic. This test was administered to both the Control and Experimental Groups at both schools during the second week of the school semester, 1969-1970. A parallel form, Y, was given the third week of May, 1970. The reliability coefficient for the total arithmetic score for this test was recorded as .87 in the test manual. Validity coefficients correlating this test with the Metropolitan Achievement Tests are .74 and .78 for Arithmetic Reasoning and Arithmetic Fundamentals, respectively.

Prior to the initial administration of all tests, students were told that they were being considered for admission to the laboratory. The Hawthorn effect was thereby eliminated.

Scores for the Otis Quick Scoring Mental Ability (Beta Test), obtained from the cumulative folder of the students, were used as the measurement of IQ.

Attitudes

A revised form of the 20-item Aiken-Dreger Math Attitude Scale was used to measure attitudes toward mathematics. Used on a college population of freshmen female students, a reliability coefficient of .92 was reported for the original scale. Some revisions of this scale were made to make the terminology more suitable for the intermediate age child. Test-retest reliability on the revised form within the experimental school district yielded a correlation coefficient of .89 with a two day time lapse between testings. Ninety-seven (97) matched scores were used for determining the reliability for the revised form.

The instrument used was a 5 point Likert-type scale including 10 positive and 10 negative items, allowing an eighty point range. A score of 40 would indicate a neutral attitude toward mathematics. A higher score indicates a more positive attitude toward mathematics. This test was administered to all students in both the experimental and control groups at each school during the second week of September (1969) and May (1970).

RESULTS

The population for this study was selected from grades five and six from both schools. Twenty-five students were randomly selected from each grade (5 and 6) for each school A and B to make up the two experimental groups for the study.

1. A pre and post test using the California Achievement Test Series, Arithmetic section, levels 4, 5, 6. Alternative forms were used for the pre and post testings.
2. A pre and post attitude scale was given each student at the beginning of the program and at the end. The scale used was the "Revised Math Attitude Scale" developed by Aiken-Dreyer. The test may be found in The Measurement of Attitudes, Shaw and Wright.
3. The Otis-Lennon Intelligence Test was administered to each of the students at the beginning of the program.

Table I reviews the data for Hypothesis H_1: There will be no significance between IQ scores at school A and school B.

TABLE I

Mean I.Q. Scores for Each Group of Subjects

Group	School A Experimental	School A Control	School B Experimental	School B Control
Grade 4				
Remedial	84.0	85.4	88.5	85.9
Accelerated	112.2	111.8	102.5	Not available
Grade 5				
Remedial	85.8	84.7	84.1	87.4
Accelerated	119.0	113.7	107.4	113.3
Grade 6				
Remedial	85.1	84.9	79.1	Not available
Accelerated	117.7	113.1	108.1	Not available

Table II reviews the data for hypothesis H_2: There will be no significant difference between the pre achievement of school A and school B.

TABLE II

Mean Grade Level Pre-achievement Test Scores for Each Group of Subjects

Group	School A Experimental	School A Control	School B Experimental	School B Control
Grade 4				
Remedial	3.6	3.6	3.4	3.5
Accelerated	5.4	5.6	4.8	4.9
Grade 5				
Remedial	4.6	4.5	4.2	4.5
Accelerated	6.8	6.7	6.0	5.9
Grade 6				
Remedial	5.2	5.0	4.7	Not available
Accelerated	7.5	7.9	6.9	7.0

A simple Analysis of Covariance was used to determine the significant difference between IQ and pre-achievement scores between schools by grade level. An F-ratio of 3.74 and 2.30 for grades 5 and 6, respectively, was found not to be significant at the .05 level.

A two-way Analysis of Variance with repeated measures on one variable was used to test the hypothesis; There will be no significant difference between pre and post achievement in mathematics for each

school. This analysis was made on the total laboratory population for each grade level, and also for the remedial students only, and the academically talented students only.

A two-way Analysis of Variance with repeated measures on one variable was also used to analyze differences in achievement by grades between schools and also for analyzing differences between the total laboratory population at school A and at school B. Such an analysis was used for testing these hypothesis for remedial students only, and also for academically talented students only.

A two-way ANOVA with repeated measures on one variable was used to determine the sign difference in mathematics achievement of 1) total laboratory population when compared with a control group for each grade level at each school; 2) accelerated laboratory students when compared with accelerated control groups by grade level at each school; 3) remedial laboratory students when compared with remedial control groups by grade level at each school.

An F value of 159.236 revealed a significant difference at the .01 level between pre-and post-achievement scores at school A. No evidence of significance at the .05 level was found between grades, nor in interaction of the groups within the analysis.

An F value of 91.696 revealed a significant difference at the .01 level between pre- and post-achievement scores at school B. No other significant differences were found for this analysis.

The following tables show the comparative achievement data.

TABLE III

A Comparison of Grade Equivalent Changes in Mathematics Achievement for Remedial Students

Grade	School A Experimental	School A Control	School B Experimental	School B Control
Grade 4				
Pre	3.6	3.6	3.4	3.5
Post	4.8	4.4	4.5	4.5
Difference	12.2	8.0	12.1	12.0
Grade 5				
Pre	4.6	4.5	4.2	4.5
Post	5.7	5.3	5.1	5.3
Difference	12.1	8.0	9.0	8.0
Grade 6				
Pre	5.2	5.0	4.7	Not
Post	6.0	5.7	5.3	Available
Difference	8.0	7.0	6.0	

TABLE IV

A Comparison of Grade Equivalent Changes in Mathematics Achievement for Accelerated Students

Grade	School A Experimental	School A Control	School A and School B Combined
Grade 4			
Pre	5.4	5.6	4.8
Post	6.8	6.8	6.0
Difference	12.4	12.2	12.2
Grade 5			
Pre	6.8	6.7	6.0
Post	7.7	7.3	6.8
Difference	9.0	6.0	8.0
Grade 6			
Pre	7.4	7.5	6.9
Post	8.0	7.9	7.9
Difference	6.0	4.0	12.0

TABLE V

A Comparison of Differences in Mathematics Achievement for Remedial and Accelerated Students in School A and School B by Grade Level

Grade	Mean Difference in Achievement	
	School A	School B
Grade 4		
Remedial	+ 1 yr. 2 mo.	+ 1 yr. 1 mo.
Accelerated	+ 1 yr. 4 mo.	+ 1 yr. 2 mo.
Grade 5		
Remedial	+ 1 yr. 1 mo.	+ 9 mo.
Accelerated	+ 9 mo.	+ 8 mo.
Grade 6		
Remedial	+ 8 mo.	+ 6 mo.
Accelerated	+ 6 mo.	+ 1 yr.

TABLE VI

Means and Analysis of Variance for Mathematics Achievement Measured at the Beginning and End of the School Year

Exp. Students	School A Pre	School A Post	School B Pre	School B Post	F - Ratios School	F - Ratios Pre-Post	F - Ratios Interaction
Grade 5	54.1	72.7	43.6	58.8	0.522	160.878++	1.713
Grade 6	65.1	79.1	56.0	71.4	0.325	88.429++	0.230
Accelerated Students							
Grade 4	52.9	77.0	42.4	62.9	0.304	103.633++	0.673
Grade 5	76.5	95.8	61.5	75.6	0.002	29.077++	2.784
Grade 6	90.3	104.5	79.2	103.3	0.103	55.366++	3.699
Remedial Students							
Grade 4	*128.4	183.9	123.1	172.5	0.025	124.117++	0.406
Grade 5	39.1	57.2	31.7	46.9	0.283	70.405++	0.546
Grade 6	48.3	62.1	40.5	50.2	0.707	51.864++	1.609

Note: Raw scores used.
* Lower Test form used.
+ 5% sign ++ 1% sign

A two-way Analysis of Variance with repeated measures on one variable was used to test the hypothesis; There will be no significant difference between pre and post attitudes.

The analysis for school A yielded no significant values at the .05 level for F.

The analysis for school B revealed an F value of 5.593, which indicated a significant difference at the .05 level between pre and post attitude scores within the school. No evidence of difference of attitude at the .05 level was found between grades, nor between groups within the analysis.

A two-way Analysis of Variance with repeated measures on one variable was used to test the hypothesis for the total population.

The analysis for attitudes showed no significant difference at the .05 level in change by school, nor in interaction of groups within the analysis. However, an F value of 7.936 did reveal a significant change at the .01 level in attitude for the total population. Table VII illustrates the data on attitudes for one grade in the study.

TABLE VII

A Comparison of Mean Differences in Mathematics Achievement and Mean Difference in Attitude Toward Mathematics in School A and B for all Laboratory Students in Grade 5

School	Achievement			Attitude*		
	Pre	Post	Diff.	Pre	Post	Diff.
School A						
Total Experimental	5.5	6.5	+ 10 mo.	57.2	61.1	+2.9
Total Control	5.3	6.1	+ 8 mo.	54.6	52.4	-2.2
School B						
Total Experimental	4.9	5.8	+ 9 mo.	53.9	58.9	+5.0
Total Control	5.0	6.0	+ 10 mo.	54.8	58.9	+4.1

*Raw score of 40 indicates a neutral attitude toward mathematics; higher score indicates more positive attitude.

A short program was written t determine the differences in achievement for each student, the mean difference, and the variance for each grade within each school. This program was also used to determine the previously presented values for difference in attitude. Correlation techniques were used to compute the relationship between IQ and attitude change and between IQ and achivement change. Values were computed for Pearson's r, Kendall's Tau, and Spearman's Rho. All derived values for Pearson's r were found to be not significant at the .05 level when subjected to a t-test. Since Normality has not been tested, Spearman's Rho results were chosen to give more accurate results for this hypothesis. Coefficients for Rho of .387, .398, and .467 were found to be significant at the .05 level. These coefficients referred to School B, Grade 5, Achievement; School B, Grade 6, Achievement; and School B, Grade 5, Attitude.

The hypothesis: <u>There will be no significant differences between IQ scores and changes in attitude</u> and: <u>There will be no significant difference between IQ scores and change in achievement in mathematics</u> could not be rejected.

CONCLUSIONS AND COMMENTS

The data indicates that there were no significant differences between the Experimental Group and the Control Group with respect to mean IQ scores. This was also true with respect to differences between schools.

The data indicates that there was a significant gain in mathematics achievement between the pre and post test for all students in the study. There was not a significant difference in the scores of students using the laboratory and those not using the laboratory. However a review of the tables comparing the gains shows that:

Mathematics laboratories used with slow learners facilitated a slightly increased academic achievement, with more of an increase occurring at the lower grade levels.

Mathematics laboratories used with academically gifted learners facilitated a slightly increased academic achievement, with more of an increase occurring at the lower grade levels.

The data indicates that mathematics laboratories facilitated an increased positive attitude toward mathematics, with a significant increase occurring in the school located in a deprived area.

Although the data is not conclusive, there is a strong implication that mathematics laboratories that are organized to provide personal and individualized assistance are most helpful to learners that have been disadvantaged culturally and/or academically. With this population, there seems to be greater academic and attitude gains than with the more advantaged learners.